

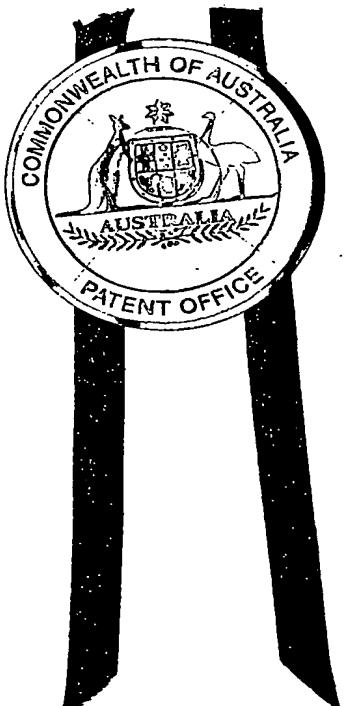
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## radPro Patent Document

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## Contents

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<b>Contents .....</b>	<b>i</b>
<b>List of Figures.....</b>	<b>i</b>
<b>1. Abstract .....</b>	<b>1</b>
<b>2. References .....</b>	<b>1</b>
<b>3. Claims .....</b>	<b>1</b>
<b>4. Description .....</b>	<b>2</b>
4.1. Invention Background .....	2
4.2. Invention Summary.....	3
4.3. Diagrams.....	4
4.3.1. <i>Exposure Limits Comparison</i> .....	4
4.3.2. <i>Power Density Comparison</i> .....	5
4.4. Detailed Description.....	6

## List of Figures

---

Figure 4.1 - Exposure limits for CTA610D-R panel (using existing techniques).....	4
Figure 4.2 - Exposure limits for CTA610D-R panel (using the new technique) .....	4
Figure 4.3 - Power Density Plot for Decibel DB580Y (using existing techniques).....	5
Figure 4.4 - Power Density Plot for Decibel DB580Y (using the new technique) .....	5

## 1. Abstract

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A method for evaluating radiating field power density of RF radiating elements using basic radiating device and input properties.

## 2. References

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- [1] Wood, Mike Et. Al., "EME Assessments Using Telstra's Mobile Base Station Field Intensity Plotter", Telstra Corporation March 2001
- [2] Saad, Theodore, "Microwave Engineers' Handbook, Volume two", Artech House 1971

## 3. Claims

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What is claimed is:

1. A method of estimating radiation power density of radio frequency electromagnetic emission devices in both near and far fields, which consists of:

Gathering the far-field gain pattern data for all radiating devices;

Gathering all physical data for the device and its configuration;

Calculating the radiated power density over an area of interest or doubt

2. A method of estimating the near-field off-axis power density, which consists of:

Gathering the physical dimensions of radiating devices;

Applying a closest point algorithm for a given analysis position;

Using the closest point to find the radiated power density at the point of analysis.

## 4. Description

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### 4.1. Invention Background

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Management of radio communications infrastructure is an important and necessary consideration for most telecommunications authorities. To abide by relevant emissions standards, maintainers of transmitting structures have the task of displaying and recording technical information about sites. Accurate radiation levels and exposure limits must be provided. Methods of radiation level estimation can offer great time and cost savings over traditional site measurings.

Existing techniques for radiation estimation include far-field only estimation, and combined far-field and point source approximated on-axis near-field estimation. The approximation for near-field estimation is performed as “Gain reduces in the near field because of the finite size of the aperture no longer focuses all the radiated energy from each part of the antenna in-phase at the point of observation” [1, p3,4.] The solution was developed from power density observations for uniform line source and tapered illumination aperture antennas documented in [2, p34,35.]

From these observations, a general break-point distance was set where calculations would change modes between near-field and far-field and a taper method was established to suit being inside the break-point zone. The break point for parabolic antennas was 0.16 times the far-field distance. The taper method for the parabolic antenna was defined as:

$$Pd_{ParabolicVF} = 41.3 * Pd,$$

where the  $D_i$  used in the  $P_d$  calculations is just  $D_{far-field}$ , irrespective of how close a distance is to the antenna. The break point for rectangular aperture antennas was defined as 0.25 times the far-field distance. The taper method for the rectangular aperture antenna was defined as:

$$Pd_{RectangularNF} = Pd,$$

where the  $D_i^2$  used in  $P_d$  is replaced with  $D_i$  times the breakpoint distance. This effectively makes the power density decay with a rate of  $1/D_i$  in the near-field, rather than  $1/D_i^2$  (which occurs in the far-field.)

## 4.2. Invention Summary

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The solution for both on and off-axis near-field calculations for all common RF emitting devices developed by iCOMMs for the RadPro product is the closest point algorithm. This algorithm was developed because it gave more accurate results in the near and far fields than previous methods, while not requiring significantly more processing power.

The principle of the closest point algorithm is that there is always only one radiating point to be calculated for, the point is merely shifted to the most appropriate position within the radiating element's aperture, to become the closest point on the antenna to the point of analysis. When viewed, this process shows the antenna having a distribution spanning the entire aperture of the antenna, while still providing accurate results once the analysis is outside of the antenna's aperture. A taper function linearly reduces the effective aperture size (in length and width) as the distance from the antenna increases, until the far-field distance is reached, at which the closest point algorithm merges back into a point source analysis. In the far-field zone of the radiating devices, the far-field gain patterns and point source techniques are appropriate.

## 4.3. Diagrams

### 4.3.1. Exposure Limits Comparison

The following diagrams display the exposure limit boundaries (using 2 and 10 W/m<sup>2</sup> for the red and yellow zones respectively) of the existing and new calculation techniques for plan (horizontal) and elevation (vertical) boresights of the test antenna, the Argus CTA610D-R.



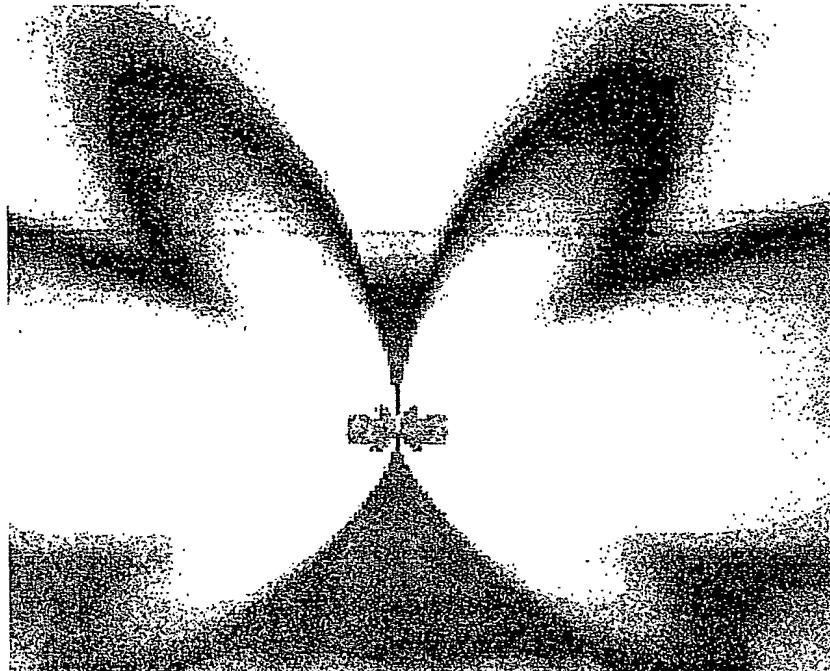
Figure 4.1 - Exposure limits for CTA610D-R panel (using existing techniques)



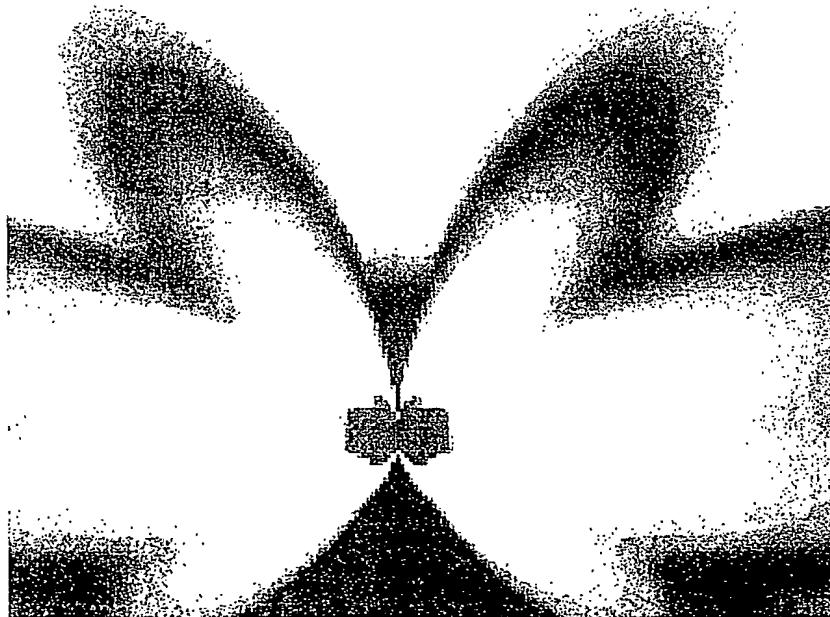
Figure 4.2 - Exposure limits for CTA610D-R panel (using the new technique)

### 4.3.2. Power Density Comparison

The following diagrams represent the power density graphical representations of the existing and new estimation algorithms for the test antennas, of the type Decibel DB580Y (omnidirectional.)



**Figure 4.3 - Power Density Plot for Decibel DB580Y (using existing techniques)**



**Figure 4.4 - Power Density Plot for Decibel DB580Y (using the new technique)**

## 4.4. Detailed Description

The closest point algorithm automatically calculates over the whole of the antenna's length and width to achieve a full three dimensional analysis of the antenna(s). This is particularly important when the analysis is not directly on the antenna's horizontal or vertical bore, such as volume analysis or for multiple antenna analysis. Previous methods could not correctly calculate for these situations.

The closest antenna algorithm is as follows:

1. Find the displacement of the analysis point and the centre of the radiating element;
2. Calculate the effective reduction of antenna aperture as a result of the displacement;
3. Find the displacement vector's x, y and z dimension values between the centre of the antenna and the point of analysis;
4. Rotate the displacement vector by the antenna's mechanical downtilt in three dimensional space (to calculate the analysis with respect to the antenna face);
5. Find the Azimuth angle (the angle in the XY plane from the centre of the antenna's aperture face to the analysis point in the X-Y plane);
6. Find the Elevation angle (the angle in the Z plane from the centre of the antenna's aperture face to the analysis point in the Z plane);
7. From the rotated displacement, obtain the analysis height going along the antenna height plane (obtained through the rotated displacement's z dimension.);
8. From the rotated displacement, obtain the analysis distance along the antenna width plane (obtained through the rotated displacement's xy plane vector's component along the antenna face)
9. If the offset (analysis displacement height + electrical downtilt compensation) is inside +/- ½ the effective antenna height, then the new source Z position is set to the antenna's centre height + the Z component of the downtilted offset

Else,

The new Z position is set to the sign of the offset \*  $\frac{1}{2}$  the effective antenna height;

10. If the antenna width plane offset is inside  $+\/- \frac{1}{2}$  the effective antenna width, then the new source X and Y positions are set to the antenna's centre X and Y positions + the width offset along the antenna face + X and Y components of the downtilted elevation offset,

Else,

The new X and Y positions are set to the sign of the offset \*  $\frac{1}{2}$  the effective antenna width.

The new antenna source positions are then used in the calculation at this analysis point.

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